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**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371**

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)

10/070395

INTERNATIONAL APPLICATION NO.  
PCT/CA00/01017

INTERNATIONAL FILING DATE  
1 SEPTEMBER 2000 (01.09.00)

PRIORITY DATE CLAIMED  
3 SEPTEMBER 1999 (03.09.99)

**TITLE OF INVENTION**

**LOW ACTIVATION TEMPERATURE ADHESIVE COMPOSITION WITH HIGH PEEL STRENGTH AND COHESIVE FAILURE**

APPLICANT(S) FOR DO/EO/US

HOJABR, Sassan et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to being national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b)) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19<sup>th</sup> month from the earliest claimed priority date.
5. ☒ A copy of the International Application was filed (35 U.S.C. 371 (c) (2))
  - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371 (c) (2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c) (3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
10. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409)
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

**Items 13 to 18 below concern document(s) or information included :**

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☐ A FIRST preliminary amendment.  
A SECOND or SUBSEQUENT preliminary amendment.
16. ☐ A substitute specification.
17. ☒ A change of power of attorney and/or address letter.
18. ☒ Certificate of Mailing by Express Mail.
19. ☐ Other items or information:

17. General Power of Attorney

18. Express Mailing Label No.: EJ376013529US

APPLICATION NO. (PCT/US/INTL) <b>10/070395</b>		INTERNATIONAL APPLICATION NO. <b>PCT/CA00/01017</b>		ATTORNEY'S DOCKET NUMBER <b>DC-0300</b>	
20. The following fees are submitted  <b>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :</b> <input checked="" type="checkbox"/> Search Report has been prepared by the EPO or JPO <span style="float:right">\$890.00</span> <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) <span style="float:right">\$710.00</span> <input type="checkbox"/> No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) <span style="float:right">\$740.00</span> <input type="checkbox"/> Neither international preliminary examination fee paid to USPTO (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO <span style="float:right">\$1,040.00</span> <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) <span style="float:right">\$100.00</span> And all claims satisfied provisions of PCT Article 33(2)-(4)				<b>CALCULATIONS PTO USE ONLY</b>	
<b>ENTER APPROPRIATE BASIC FEE AMOUNT</b> =				<b>\$890.00</b>	
Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)).				<input type="checkbox"/> 20 <input checked="" type="checkbox"/> 30	<b>\$130.00</b>
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	25 - 20 =	5	x \$18.00		\$90.00
Independent Claims	3 - 3 =	5	x \$84.00		\$0.00
Multiple Dependent Claims (check if applicable)				<input type="checkbox"/>	\$0.00
<b>TOTAL OF ABOVE CALCULATIONS</b>				=	<b>\$90.00</b>
Reduction of ½ for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable).				<input type="checkbox"/>	\$0.00
<b>SUBTOTAL</b>				=	<b>\$220.00</b>
Processing Fee of \$130.00 for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)).				<input type="checkbox"/> 20 <input type="checkbox"/> 30	\$0.00
<b>TOTAL NATIONAL FEE</b>				=	<b>\$1,110.00</b>
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable).				<input type="checkbox"/>	\$0.00
<b>TOTAL FEES ENCLOSED</b>				=	<b>\$1,110.00</b>
				Amount to be refunded	\$
				Charged	\$
<input type="checkbox"/> A check in the amount of _____ to cover the above fees enclosed. <input checked="" type="checkbox"/> Please charge my Deposit Account No. <b>04-1928</b> in the amount of <b>\$1,110.00</b> to cover the above fees. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. <b>04-1928</b> a duplicate copy of this sheet is enclosed.					
<b>NOTE :</b> Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (CFR 1.37(a) or (b)) must be filed and granted to restore the application to pending status.					
<b>SEND ALL CORRESPONDENCE TO:</b>					
STEVENSON, Robert B. E. I. DU PONT DE NEMOURS AND COMPANY Legal Patent Records Center 4417 Lancaster Pike Wilmington, Delaware 19805 United States of America			<div style="text-align: center;"> </div> SIGNATURE Neil Feltham, Reg. No. 36,506 for STEVENSON, ROBERT B. <hr/> NAME <div style="text-align: center;">26,039</div> <hr/> REGISTRATION NUMBER <div style="text-align: center;">01 MARCH 2002</div> <hr/> DATE		

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**Low Activation Temperature Adhesive Composition**  
**With High Peel Strength and Cohesive Failure**

**Field of the Invention:**

- This invention relates to new resin and adhesive compositions, and in particular to
- 5 low activation temperature adhesive compositions that can be applied as a self-supporting film or can be co-extruded or extrusion coated onto a substrate.

**Background of the Invention:**

- While it is known that acid-modified or anhydride-modified polymers are useful as adhesives for bonding to both metal and polyolefins, there is a need to have adhesives
- 10 with not only high-bond strength to both metal and polyolefins, but also to activate the bonding at relatively lower temperatures. Conventional and currently commercially available modified polyolefins sacrifice either bonding strength to the metal or to the polyolefin, or do not activate at low temperatures when bonding to metals or polyolefins. Furthermore, adhesive compositions that purport to activate at
- 15 low temperatures are often very soft and tacky materials such that the handling of these compositions as free films in thermal laminating processes is problematic and may require very costly release films to prevent blocking. Also, most current adhesives tend to significantly lose their bond strength over time after they are put into service. This phenomenon is referred to as "age-down" in the industry.
- 20 There are number of patents in the art that disclose adhesive compositions but these prior art patents are not satisfactory in every aspect mentioned in this specification. Examples of these prior art patents include United States Patent Nos. 5,516,583; 4,861,676; 4,861,677; 4,552,819; and 5,965,255.

- One example of the prior art is United States Patent No. 5,225,482 issued July 6, 1993
- 25 to Nakagawa et al, which discloses an adhesive composition comprising an ethylene-vinyl acetate copolymer, a styrene polymer resin, a graft-modified polyethylene, a polystyrene elastomer and an ethylene- $\alpha$ -olefin copolymer. There is no disclosure of the use of high impact polystyrene as the styrene resin in combination with an olefin/non-olefin copolymer.

It has been found that the formulations for the adhesive compositions of the present invention solve many, or all, of these problems. The adhesive compositions of the present invention bond to both metal and polyolefins, activate at relatively lower temperatures and are easily handled as a free or coextruded film not requiring interleafing or a release paper. In addition, it has been found that these adhesive compositions fail 100% cohesively during the peel test. Cohesive failure is a desirable attribute in that it can be an indicator of high bond strength, so much so that the bond strength is greater than the cohesive strength of the adhesive. Cohesive failure also provides a convenient visual test to assure that multi-layer constructions are properly bonded when other testing methods are not readily available. Finally there appears to be a strong correlation between the cohesive failure mode of the adhesive and the retention of bond strength after the product is put into service.

Accordingly, the present invention provides adhesive compositions that possess excellent bonding properties to metallic substrates and to a number of polymeric materials resulting in an adhesive layer with high peel strength. The present invention also allows for a relatively lower activation temperature to be used in the manufacture of building panels.

The adhesive compositions of the present invention may be supplied as an adhesive resin in pellet form or as an adhesive film.

#### 20 **Summary of the Invention:**

Accordingly, in one aspect of the present invention, there is provided a resin composition made from admixing starting materials comprising:

- (a) 0 to 90 parts by weight of a polyolefin;
  - (b) 5 to 95 parts by weight of a functional polyolefin;
  - (c) 5 to 40 parts by weight of a polystyrenic; and
  - (d) 0 to 30 parts by weight of an elastomer,
- where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.

In a second aspect of the present invention, there is provided a resin composition made from admixing starting materials comprising:

- (a) 0 to 90 parts by weight of a non-olefin copolymer;
  - (b) 5 to 95 parts by weight of a functional polyolefin;
  - 5 (c) 5 to 40 parts by weight of high impact polystyrene; and
  - (e) 0 to 30 parts by weight of an elastomer,
- where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.

**Brief Description of the Drawings:**

- 10 The preferred embodiments of the present invention will be described with reference to the accompanying drawings in which like numerals refer to the same parts in the several views and in which:

Figures 1a and 1b are schematic views of a five-layer laminated structure made using one embodiment of the adhesive composition of the present invention.

15 **Detailed Description of the Preferred Embodiments:**

The present invention will be described with reference to its preferred embodiments.

- The preferred resin and adhesive compositions of the present invention as described herein are melt blends of a number of polymers. These adhesives can be used in various kinds of applications and possess varying properties depending on the specific
- 20 application. One application for these preferred adhesives is in manufacturing metal panels for the construction industry in which the panels are in the form of a composite structure comprising metal substrates such as aluminum or steel bonded to a polyolefin core such as polyethylene. The preferred adhesive compositions of the present invention are used to bond the metal substrates to the polyethylene core.
- 25 In such an application, it is important for the adhesive layer to provide excellent adhesion of the polyolefin to the metal substrate. As well, it is desirable that the adhesive fail cohesively during application, and should be relatively easy to formulate and use. It has been found that the adhesive compositions of the present invention

provide excellent adhesion to metallic substrates and to a number of polymeric materials. They fail 100% cohesively during the peel test. The adhesive compositions can be used as self-supporting films, making them easy to handle and process.

- The preferred adhesive compositions of the present invention activate at lower temperatures than adhesives currently used in manufacturing building panels. For the preferred adhesive compositions, the activation temperature can be lowered down to about 125 °C. This lowering of the activation temperature results in considerable cost savings and safer operations for panel manufacturers because the use of protective layers for painted surfaces (which are needed at higher temperatures to prevent mottling of the paint) can be eliminated from the manufacturing process.

In one aspect, the resin composition of the present invention comprises:

- a) 0 to 90 parts by weight of a polyolefin;
  - b) 5 to 95 parts by weight of a functional polyolefin;
  - c) 5 to 40 parts by weight of a polystyrenic; and
  - d) 0 to 30 parts by weight of an elastomer,
- where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.

In a second aspect, the resin composition of the present invention comprises:

- a) 0 to 90 parts by weight of a non-olefin copolymer;
  - b) 5 to 95 parts by weight of a functional polyolefin;
  - c) 5 to 40 parts by weight of high impact polystyrene; and
  - e) 0 to 30 parts by weight of an elastomer,
- where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.

- In this patent specification, the term "polyolefin" means homopolymers and copolymers of olefins. More specifically, homopolymers include polymers consisting of a single unsaturated olefin such as polyethylene, polypropylene, polybutene or the like where the olefin has 2-20 carbon atoms. Copolymers of olefins include polymers

consisting of one or more unsaturated or multiply unsaturated hydrocarbons having 2-20 carbon atoms. Examples include, but are not limited to ethylene/propylene copolymers, ethylene/butene copolymers, ethylene/hexene copolymers, ethylene/octene copolymers, ethylene/styrene copolymers, ethylene/butene/octene  
5 copolymers, ethylene/propylene/norbornadiene copolymers and propylene/butene copolymers.

In this patent specification, the term "non-olefin copolymer" refers to copolymers of olefins with non-olefins. Non-olefins that can be copolymerized with olefins, principally ethylene, include but are not limited to: vinyl acetate, acrylate or  
10 methacrylate esters having 1-20 carbon atoms, unsaturated anhydrides such as maleic or itaconic anhydride, unsaturated acids such as maleic, fumaric, acrylic, methacrylic or itaconic acid. Examples of copolymers of olefins and non-olefins include, but are not limited to: ethylene/vinyl acetate, ethylene/methylacrylate, ethylene/butylacrylate. These polymers can be made by processes well known in the art, including the use of  
15 metallocene catalysts, Ziegler Natta catalysts and other catalysts useful in "low pressure" polymerization processes. Conversely, these polymers may be made in "high pressure" polymerization processes using, for example, free radical initiators. Mixtures and blends of the Polyolefins may be used.

In this patent specification, the term "functional polyolefin" refers to a polyolefin or a  
20 non-olefin copolymer that has specific functional groups capable of reacting to form covalent or ionic bonds. A functional polyolefin includes a "grafted polyolefin" as defined below.

The term "grafted polyolefin" refers to a polyolefin, to a non-olefin copolymer or to a mixture or blend of polyolefins and/or non-olefin copolymers, onto which is grafted at  
25 least one monomer selected from ethylenically unsaturated carboxylic acids and ethylenically unsaturated carboxylic acid anhydrides, including less preferably, derivatives of such acids, and mixtures thereof. Examples of the acids and anhydrides, which may be mono-, di- or polycarboxylic acids are acrylic acid, methacrylic acid, maleic acid, fumaric acid, itaconic acid, crotonic acid, itaconic anhydride, maleic  
30 anhydride and substituted maleic anhydride, e.g. dimethyl maleic anhydride or

citrotronic anhydride, nadic anhydride, nadic methyl anhydride, and tetrahydrophthalic anhydride, maleic anhydride being particularly preferred. Examples of the derivatives of the unsaturated acids are salts, amides, imides and esters, e.g., mono- and disodium maleate, acrylamide, glycidyl methacrylate and dimethyl fumarate. Grafted

- 5 polyolefins are well known in the art and can be produced by a variety of processes including thermal grafting in an extruder or other mixing device, grafting in solution or grafting in a fluidized bed reactor. Blends or mixtures of grafted polyolefins may also be used.

- In this patent specification, the term "polystyrenic" refers to homopolymers of  
10 styrene or alpha methylstyrene or copolymers of styrene with unsaturated monomers such as, but not limited to: ethylene, butene, butadiene, or isoprene. Specific examples include, but are not limited to: ethylene/styrene random or block copolymers, ethylene/butadiene random or block copolymers and hydrogenated and partially hydrogenated butadiene/styrene copolymers. Also useful are polystyrenics further  
15 modified for enhanced impact properties and usually referred to as High Impact Polystyrene or HIPS. Blends and mixtures of polystyrenics may also be used. Specific examples include, but are not limited to, High Performance Stryrenics sold by Nova Chemicals and ethylene/styrene copolymers sold by Dow Chemical under the name Index™.

- 20 In this patent specification, the term "elastomer" also refers to a polyolefin or polystyrenic but is distinguished from polyolefin or polystyrenic as described above in having a relatively low level of crystallinity, that is, in being relatively amorphous. Elastomers by definition herein will have a heat of fusion, as measured by Differential Scanning Calorimetry (DSC), at 10 degrees centigrade per minute heating rate, of less  
25 than 30 joules/gram. A polyolefin elastomer, for example, may be a copolymer of ethylene and an alpha olefin and would include low density metallocene ethylene/butene copolymers sold by ExxonMobil under the name "Exact®" or metallocene ethylene/octene copolymers sold by DuPont Dow Elastomers under the name "Engage®". It would also include ethylene/propylene copolymers sold by  
30 ExxonMobil under the name "Vistalon®", ethylene/alpha olefin copolymer sold by



Mitsui under the name "Tafmer®" or ethylene/propylene/norbornadiene copolymers sold by DuPont Dow Elastomers under the name of "Nordel®". It would also include polybutene rubber, polyisobutylene. Examples of a polystyrenic elastomer would include, for example, di-block and tri-block copolymers sold by Shell under the name  
5 "Kraton®" or those sold by Firestone under the name "Stereon®".

In addition to the above-mentioned components, the preferred adhesive compositions of the present invention may contain small amounts of other materials commonly used and well known in the adhesive art. These materials include, for example, primary and secondary antioxidants, stabilizers, slip additives, antiblock additives such as  
10 silica or talc, dyes, pigments and tackifying resins such as those described in the Kirk Othmer Encyclopedia of Chemical Technology, so long as the addition of these additives does not significantly adversely affect the adhesive qualities of the composition.

The adhesive compositions of the present invention can be dry blended and  
15 subsequently melt blended in a twin screw extruder and repelletized as is well known in the art. Subsequently, these melt blended resins can be converted and applied by a variety of techniques and processes. For example, the adhesive can be converted into a film by cast or blown film die extrusion techniques and this adhesive film can be laminated to appropriate substrates such as metals or polyolefins. As an alternative,  
20 the adhesive composition can be coextruded with other polyolefins as a skin layer on either one or both surfaces of the polyolefin to produce a more economical adhesive film.

As a further alternative, a coextruded film can be created incorporating polar barrier resins such as polyamides, ethylene vinyl alcohol copolymer (EVOH) or polyester  
25 using the adhesive compositions of the present invention to bond directly to the polar barrier material. These adhesive films can be laminated to various substrates by heat activating the adhesive film. Heat activation can be done by a variety of methods including, but not limited to, direct contact with a heated plate or roller, absorption of infrared energy, direct heating in an oven or activation through RF frequency or  
30 microwave radiation.

In another application for the adhesive compositions of the present invention, the adhesive can be directly coated onto a substrate in processes well known in the art, including, for example, extrusion lamination, extrusion coating, coextrusion lamination and coextrusion coating. The adhesive composition of the present invention can be used to bond to polar barrier resins, such as EVOH, polyamide or polyester. It can also be used to bond to metals, such as steel, aluminum, copper and brass, and to polyolefins such as polyethylene, ethylene copolymers and polypropylene.

In one preferred embodiment of the present invention, a resin composition is provided made from starting materials that comprise the following components:

- (a) 0 to 90 parts by weight, and more preferably 20 to 60 parts by weight, of linear low density polyethylene (for example, commercially available under the name Exact® from ExxonMobil or under the name Sclair® from Nova Chemicals);
- 15 (b) 5 to 95 parts by weight, and more preferably 10 to 30 parts by weight, of maleic anhydride grafted polyethylene (for example, commercially available under the name Fusabond® from DuPont);
- (c) 5 to 40 parts by weight, and more preferably 10 to 35 parts by weight, of high impact polystyrene (for example, commercially available as High Performance Styrenics from Nova Chemicals); and
- 20 (d) 0 to 30 parts by weight, and more preferably 10 to 25 parts by weight, of an ethylene-propylene diene rubber compound (for example, commercially available under the name Nordel IP® from DuPont-Dow Elastomers);
- 25 where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.

In a second embodiment of the present invention, an adhesive composition is provided that comprises the following components:

- (a) 0 to 90 parts by weight, and more preferably 40 to 60 parts by weight, of ethylene vinyl acetate copolymer preferably having 3 to 40 wt% of vinyl acetate, and more preferably, 5 to 30 wt% of vinyl acetate (an example of a suitable commercially available ethylene vinyl acetate copolymer is sold under the name Elvax® by DuPont);
- (b) 5 to 95 parts by weight, and more preferably 10 to 30 parts by weight, of maleic anhydride grafted polyethylene (for example, commercially available under the name Fusabond ® from DuPont);
- (c) 5 to 40 parts by weight, and more preferably 10 to 35 parts by weight, of high impact polystyrene (for example, commercially available as High Performance Styrenics from Nova Chemicals); and
- (d) 0 to 30 parts by weight, and more preferably 10 to 25 parts by weight, of an ethylene-propylene diene rubber compound (for example, commercially available under the name Nordel IP® from DuPont-Dow Elastomers);

where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.

- 20 In these two preferred embodiments of the present invention, polyisobutylene may be used instead of the ethylene-propylene diene elastomer compound. As well, polystyrenic styrene-butadiene elastomer having different butadiene contents may be used with similar effects.

- 25 Each component of the adhesive compositions of the present invention preferably provides certain attributes to the final adhesive. The low melting point polyolefin, such as polyethylene or ethylene vinyl acetate copolymer, enhances the low activation temperature property of the adhesive. The grafted polymer mainly contributes to the superior bonding of the adhesive composition to metal substrates. The elastomer component enhances its resistance to debonding and increases toughness of the final

adhesive compositions. Finally, the polystyrenic component provides the superior cohesive failure properties, as well as, surprisingly, higher bonding properties.

The preferred adhesive compositions of the present invention can have melt flow rates between 0.1 to 100 dg/min, more preferably from 0.5 to 50 dg/min and most preferably from 0.8 to 25 dg/min., as measured by ASTM-1238E. The peak melting point, as measured by DSC, can be between 55 °C- 140 °C depending on the composition.

Because of their unique combination of high peel strength, low surface tack when processed into films and bonding at low temperature, the preferred adhesives of the present invention are useful in the manufacture of aluminum and steel building panels.

#### Examples:

The following examples show the surprising advantages of using a polystyrenic such as high impact polystyrene (HIPS) in providing additional peel strength, cohesive mode of failure and a non-tacky adhesive film.

#### Example 1:

Table 1 shows the compositions 1A, 1B and 1C at 0 wt%, 10 wt% and 20 wt% High Impact Polystyrene ("HIPS") respectively. These compositions were dry-blended initially and fed to a small co-rotating twin-screw extruder. The melt-compounded materials were pelletized and then blown into film with an average thickness of about 75 microns. The films were subsequently used as adhesive layers to make a 5 layer composite structure as shown in Figures 1a and 1b. The aluminium was aludynite treated and had a thickness of 0.38 mm. The polyethylene core used was low-density polyethylene (LDPE) sheet, 2 mm thick.

The lamination of the structures were carried out in a electrically heated press as follows (Figure 1a and 1b):

- 1- Preheat the 5-layer structure for 4.5 min. @ 100 °C.
- 2- Apply pressure of 5 kgf/cm<sup>2</sup> at 135 °C for 20 seconds.

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3- Release the pressure and leave the composite in the press for an additional 1.5 min. @ 135°C.

4- Air cool the sample to room temperature.

The composite structure was then tested to measure the peel strength (ASTM 1876) using an Instron™ machine. The following conditions were used during the peel strength test:

- i) Crosshead speed: 100 mm/min.
- ii) Peel mode: 180°

The last two columns in Table 1 indicate the results of the peel strength and failure mode as the amount of Component d (HIPS) is increased from 0 wt% to 20 wt%. Comparing composition 1A with compositions 1B and 1C, the surprising effect of peel strength enhancement due to the presence of the polystyrenic HIPS component can be seen. It is also highly desirable to achieve a cohesive failure (50/50 to polyethylene and aluminum respectively). Sample 1C shows 80% cohesive failure as compared to adhesive failure in the other two compositions.

Table 1: MonoLayer Ethylene Vinyl Acetate (EVA) based Adhesives

ID#	1A	1B	1C
Comp. (a)	49.9	39.9	29.9
Comp. (b)	30.0	30.0	30.0
Comp. (c)	20.0	20.0	20.0
Comp. (d)	0.0%	10.0	20.0
Comp. (e)	0.1	0.1	0.1
Tensile Strength at Break (MPa)	16.4	23.6	29.8
Adhesive to Aluminum			
Adhesive to Aluminum			
80% Cohesive			

Component (a) = Ethylene vinyl acetate (EVA) copolymer with 12% VA content and MI of 2.5 dg/min.  
 Component (b) = Linear low-density polyethylene (LLDPE) grafted with maleic anhydride at 0.94% and MI of 2.5 dg/min.  
 Component (c) = Ethylene/propylene/norbornadiene copolymers (EPDM) Elastomers with Moony Viscosity of 20.  
 Component (d) = Polybutadiene impact modified polystyrene (HIPS) Elastomers  
 Component (e) = Hindered polyphenol antioxidant stabilizer

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**Example 2:**

Samples were prepared as described in Example 1 with the exception that co-extruded blown films of polyethylene/Adhesive were made and substituted for a pure adhesive film in order to reduce the cost of the adhesive used. The compositions 2A, 2B and

5 2C are co-extruded with a linear low density polyethylene (LLDPE) producing LLDPE-Adhesive (each layer being 25 micron thick). The results are summarized in Table 2. The co-extruded films generally result in lower peel strength as can be seen comparing 1C vs. 2A (29.8 vs. 16.5 kgf/25mm, respectively) but they are still

10 lower the peel strength. The addition of high impact polystyrene at 30wt% level (2C) appears to lower the peel strength. This latter composition is still functional though not optimal.

ID#	Comp (A)	Comp (B)	Comp (C)	Comp (D)	Comp (E)	Per Strength Regulation	Relative Moisture
2A	29.9	30.0	20.0	20.0	0.1	16.5	100% Cohesive
2B	44.9	20.0	15.0	20.0	0.1	17.5	100% Cohesive
2C	34.9	20.0	15.0	30.0	0.1	10.9	100% Cohesive

Component (a) = Metalocene ethylene butene copolymer with 0.905 density and MI of 4.5 dg/min.  
 Component (b) = High-density polyethylene (HDPE) grafted with maleic anhydride at 1.0 wt% and MI of 11 dg/min.  
 Component (c) = Ethylene/propylene/norbornene copolymers (EPDM) Elastomers with Moony Viscosity of 20.  
 Component (d) = Polybutadiene impact modified polystyrene (HIPS) Elastomers  
 Component (e) = Hindered polyphenol antioxidant stabilizer



**Example 3:**

- In this example, compositions were made using metallocene linear low-density polyethylene as the base resin. Table 3 summarises the compositions. Samples 3A, 3B and 3C were prepared as those described in Examples 1 and 2. The last two compositions 3D and 3E were prepared in a 2-step process, in order to more closely simulate an actual commercial production. Adhesives of 3D and 3E were initially laminated to aluminium at a temperature of 149 °C, using a pressure of 8.5 kgf/cm<sup>2</sup> for 30 seconds. These pre-laminated aluminium sheets were then pressed with a pre-heated LDPE core at 132°C, using a pressure of 8.5 kgf/cm<sup>2</sup> for 10 seconds. The peel testing was performed at a 90° angle as opposed to the 180° angle used in the other examples. Composition 3D is a repeat of 3C and is used to compare the performance between the different lamination and testing methods. Sample 3D represents much lower peel strength than 3C due to 180° peel test vs. a 90° peel for sample 3C.
- 15 Once again increasing the amount of impact modified polystyrene (HIPS) from 0wt% - 20wt% (comparing samples 3A to 3C) resulted in significant increase in peel strength. The mode of failure also improved and become more cohesive. Sample 3E, containing 30% HIPS, shows a high peel strength value (20.5 kgf/25 mm in 90° peel mode) and 00% cohesive failure. It should be noted that products currently used in commercial production totally fail when using this "low lamination temperature" of about 132°C.
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Table 3: Metallocene LLDPE based Adhesives:

ID	Vol. (g)	Comp. (a)	Comp. (b)	Comp. (c)	Comp. (d)	Comp. (e)	Test Strength (N/mm <sup>2</sup> )	Adhesive Medium
3A	59.9	20.0	20.0	0.0	0.10	0.10	N/A	Adhesive To Aluminum
3B	49.9	20.0	20.0	10.0	0.10	0.10	26.9	Adhesive To Aluminum
3C	39.9	20.0	20.0	20.0	0.10	0.10	36.3	20% Cohesive
3D	39.9	20.0	20.0	20.0	0.10	0.10	18.6	30% Cohesive
3E	29.9	20.0	20.0	30.0	0.10	0.10	20.5	100% Cohesive

Component (a) = Metallocene ethylene butene copolymer with 0.905 density and MI of 4.5 dg/min.  
 Component (b) = High-density polyethylene (HDPE) grafted with maleic anhydride at 1.0 wt% and MI of 11 dg/min.  
 Component (c) = Ethylene/propylene/norbornadiene copolymers (EPDM) Elastomers with Moony Viscosity of 20.  
 Component (d) = Polybutadiene impact modified polystyrene (HIPS) Elastomers  
 Component (e) = Hindered polyphenol antioxidant stabilizer

Although the present invention has been shown and described with respect to its preferred embodiments, it will be understood by those skilled in the art that other changes, modifications, additions and omissions may be made without departing from the substance and the scope of the present invention as defined by the attached claims.

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**What is Claimed is:**

1. A resin composition made from admixing starting materials comprising:
  - (a) 0 to 90 parts by weight of a polyolefin;
  - (b) 5 to 95 parts by weight of a functional polyolefin;
  - (c) 5 to 40 parts by weight of a polystyrenic; and
  - (d) 1 to 30 parts by weight of an elastomer,where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.
2. The resin of claim 1 wherein the polystyrenic is selected from the group consisting of a homopolymer of styrene and a copolymer of styrene with unsaturated monomers.
3. The resin of claim 1 wherein the polystyrenic is high impact polystyrene.
4. The resin of claim 1 wherein the polystyrenic is a blend of two or more different polystyrenics.
5. The resin of claim 1 wherein the polystyrenic is a copolymer of styrene with a monomer selected from the group consisting of ethylene, butene, butadiene or isoprene.
6. The resin of claim 5 wherein the polystyrenic is selected from the group consisting of ethylene/styrene random or block copolymers, ethylene/butadiene random or block copolymer and and hydrogenated and partially hydrogenated butadiene/styrene copolymers.
7. The resin composition of claim 1, wherein the functional polyolefin is a grafted polyolefin.
8. The resin composition of claim 3, wherein the functional polyolefin is a grafted polyolefin.

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9. A resin composition made from admixing starting materials comprising:
- (a) 0 to 90 parts by weight of polyethylene;
  - (b) 5 to 95 parts by weight of maleic anhydride grafted polyethylene;
  - (c) 5 to 40 parts by weight of high impact polystyrene; and
  - (d) 1 to 30 parts by weight of an elastomer selected from the group consisting of ethylene-propylene elastomer, ethylene-propylene diene elastomer, polyisobutylene and polyisobutylene styrene-butadiene elastomer,
- where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.
10. The resin composition of claim 9 made from admixing starting materials comprising:
- (a) 40 to 60 parts by weight of polyethylene;
  - (b) 10 to 30 parts by weight of maleic anhydride grafted polyethylene;
  - (c) 10 to 35 parts by weight of the high impact polystyrene; and
  - (c) 10 to 25 parts by weight of the elastomer compound,
- where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.
11. The resin composition of claim 10 wherein the polyethylene comprises one or more of high density polyethylene, linear low density polyethylene and low density polyethylene.
12. The resin composition of claim 7 wherein the grafted polyethylene is selected from the group consisting of maleic anhydride grafted linear low density polyethylene, maleic anhydride low density polyethylene, maleic anhydride grafted high density polyethylene.
13. A resin composition made from admixing starting materials comprising:
- (a) 0 to 90 parts by weight of a non-olefin copolymer;

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- (b) 5 to 95 parts by weight of a functional polyolefin;
- (c) 5 to 40 parts by weight of high impact polystyrene; and
- (e) 1 to 30 parts by weight of an elastomer,

where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight and wherein the resin composition is free of a tackifier.

- 14. The resin composition of claim 13, wherein the non-olefin copolymer is ethylene vinyl acetate copolymer.
- 15. The resin composition of claim 13 wherein the grafted polyethylene is selected from the group consisting of maleic anhydride grafted linear low density polyethylene, maleic anhydride grafted low density polyethylene and maleic anhydride grafted high density polyethylene.
- 16. The resin composition of claim 15, wherein the functional polyolefin is maleic anhydride grafted polyethylene.
- 17. The resin composition of claim 13, comprising:
  - (a) 40 to 60 parts by weight of ethylene vinyl acetate copolymer;
  - (b) 10 to 30 parts by weight of maleic anhydride grafted polyethylene;
  - (d) 10 to 35 parts by weight of high impact polystyrene; and
  - (d) 10 to 20 parts by weight of an elastomer compound.where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight.
- 18. The resin composition of claim 17 wherein the ethylene vinyl acetate copolymer contains 3 to 40wt% vinyl acetate.
- 19. The resin composition of claim 18 wherein the ethylene vinyl acetate copolymer contains 5 to 30 wt% vinyl acetate.
- 20. An adhesive composition comprising the resin of claim 1.

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21. An adhesive composition comprising the resin of claim 9.
22. An adhesive composition comprising the resin of claim 13.
23. A composite structure comprising:
- (a) a metal substrate;
  - (b) a polymeric layer; and
  - (c) a layer of the adhesive composition of claim 20 between the metal substrate and the polymeric layer.
24. A composite structure comprising:
- (a) a metal substrate;
  - (b) a polymeric layer; and
  - (c) a layer of the adhesive composition of claim 21 between the metal substrate and the polymeric layer.
25. A composite structure comprising:
- (a) a metal substrate;
  - (b) a polymeric layer; and
  - (c) a layer of the adhesive composition of claim 22 between the metal substrate and the polymeric layer.

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(54) Title: LOW ACTIVATION TEMPERATURE ADHESIVE COMPOSITION WITH HIGH PEEL STRENGTH AND COHE-  
SIVE FAILURE

Figure 1a - Components of 5-layer Aluminum Panel Structure

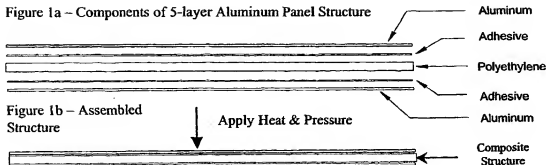


Figure 1b - Assembled Structure

Apply Heat & Pressure



(57) Abstract: The present invention provides a resin composition made from admixing starting materials comprising: (a) 0 to 90 parts by weight of a polyolefin; (b) 5 to 95 parts by weight of a functional polyolefin; (c) 5 to 40 parts by weight of a polystyrenic; and (d) 0 to 30 parts by weight of an elastomer, where the total amount of components of (a), (b), (c) and (d) in the resin composition is 100 parts by weight. In a further embodiment, component (a) is a non-olefin copolymer and component (c) is high impact polystyrene. The resin compositions are useful as adhesives for metal and polyolefin substrates.

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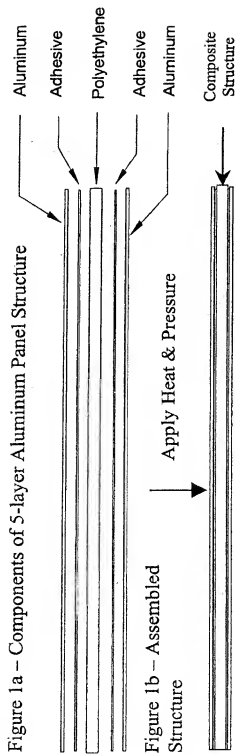


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Figure 1:



#4

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As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**LOW ACTIVATION TEMPERATURE ADHESIVE****COMPOSITION WITH HIGH PEEL STRENGTH AND COHESIVE FAILURE**

the specification of which is attached hereto unless the following box is checked:

☒ was filed on **SEPTEMBER 1, 2000** as U.S. Application No. \_\_\_\_\_ or PCT International Application No.

**PCT/CA00/01017** and was amended on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is known to me to be material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Application No.	Country	Filing Date	Priority Claimed (Yes/No)
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I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States Provisional Application(s) listed below.

U.S. Provisional Application No.	U.S. Filing Date
60/152,539	09/03/99

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International Application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application or PCT International Application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is known to me to be material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

Application No.	Filing Date	Status (patented, pending or abandoned)
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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E. I. DU PONT DE NEMOURS AND COMPANY

By: 

Vernon R. Rice  
Vice President and Assistant General Counsel

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